



# Commercial Crew Program Status Update



Commercial Crew Program

Jan. 9, 2013



# Program Status Update

- ❖ Provide update on Commercial Crew Program Progress
- ❖ Partnership Accomplishments and Plans 2012-2013
  - Blue Origin
  - The Boeing Company
  - Sierra Nevada Corp. (SNC) Space Systems
  - Space Exploration Technologies (SpaceX)
- ❖ Initiation of the CCP Certification Products Contracts
- ❖ Planning for the final development and certification effort

National Aeronautics and Space Administration



# Commercial Crew Program A Multifaceted Partnership

Jan. 9, 2013  
Philip McAlister  
NASA Headquarters



# Overview



- The goal of the Commercial Crew Program is to facilitate the development of a U.S. commercial crew space transportation capability with the goal of achieving safe, reliable and cost-effective access to and from low-Earth orbit and the International Space Station.



The Gherkin, London. Credit: Ed Traves Photo Archive at Temple University; [www.edtraves.com](http://www.edtraves.com)

- In order to accomplish this goal, NASA has created a multifaceted partnership between the government and industry, featuring:
  1. Financial Investments
  2. Milestones and Quarterly Reviews
  3. NASA Partner Integration Teams
  4. Technical Interchange Meetings
  5. Reimbursable Space Act Agreements
  6. Data Sharing
  7. Requirements Application

# Financial Investments To Date

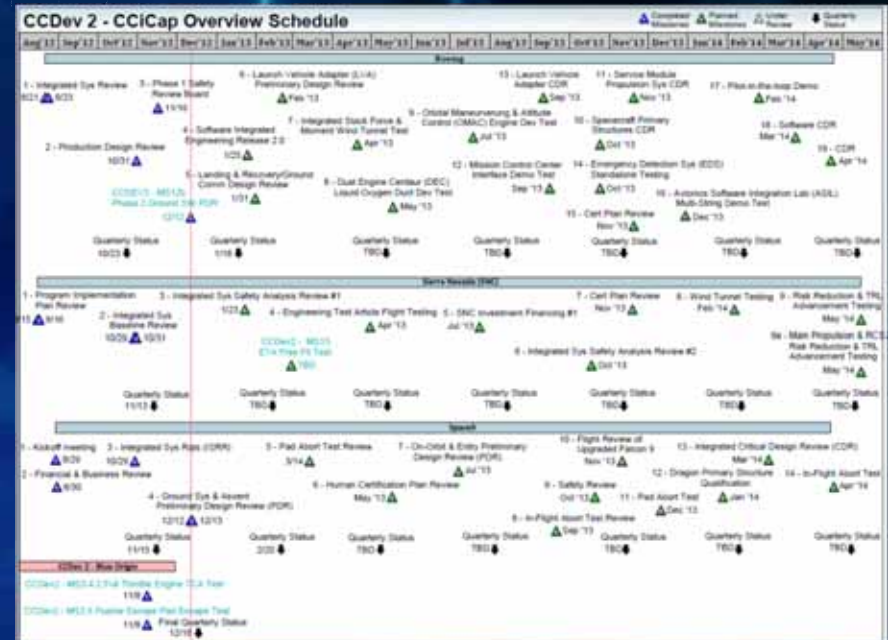


- Commercial Crew Development Round 1 (CCDev1) – \$50M total
  - Partners (5): Blue Origin, Boeing, Paragon, SNC, ULA
  - Scope: Crew Transportation System Technologies and Concepts
- Commercial Crew Development Round 2 (CCDev2) – \$315M total
  - Partners (4): Blue Origin, Boeing, SNC, SpaceX
  - Scope: Elements of a Crew Transportation System
- Commercial Crew Integrated Capability (CCiCap) – \$1.1B total
  - Partners (3): Boeing, SNC, SpaceX
  - Scope: Integrated Crew Transportation Systems
- Certification Products Contract (CPC) – \$29.6M total
  - Partners (3): Boeing, SNC, SpaceX
  - Scope: Early Certification Products

# Milestones and Quarterly Reviews



- Milestones are the formal items associated with the Space Act Agreements that allow NASA to assess partner progress and accomplishment of the milestone entrance and exit criteria.
- Payments are made only after partner demonstrates that the milestone criteria have been successfully met.
- Quarterly Reviews cover technical progress made; milestone expectations for upcoming quarter; current risk assessment; any life cycle cost changes; plans forward; and any difficulties encountered and the corrective actions necessary to recover.

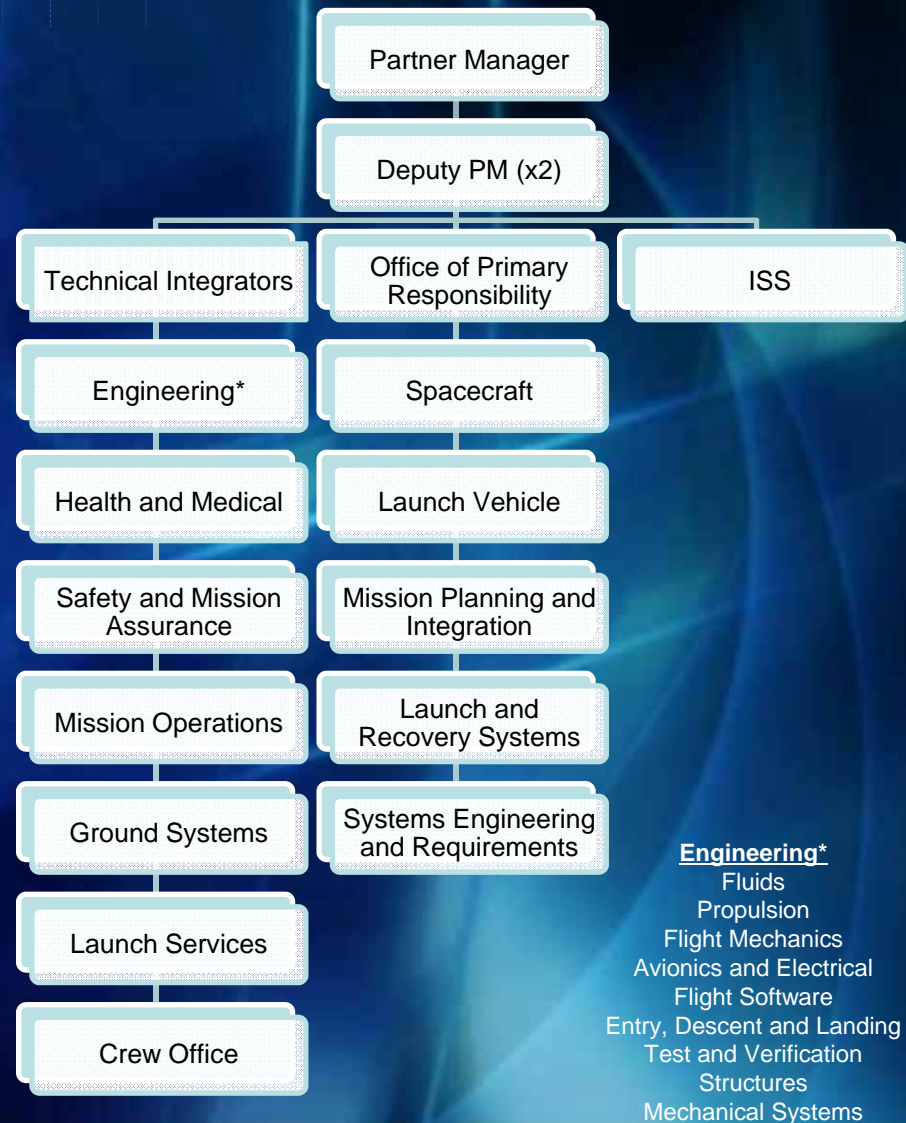


CCP Milestone and Quarterly Review Schedule

# NASA Partner Integration Teams



- NASA's Partner Integration Teams consist of technical experts in a variety of subject matters from across the agency.
- These technical experts:
  - Assist in milestone evaluation
  - Provide industry partners with human spaceflight technical expertise and experience
  - Provide NASA with a working-level understanding of industry's designs



# Technical Interchange Meetings



- Technical Interchange Meetings (TIMs) are informal forums where NASA and industry experts meet to discuss detailed topics in a collaborative fashion where a free exchange of ideas is encouraged.
- TIMs allow quick identification and resolution of technical issues at an engineer-to-engineer level.
- NASA and its commercial crew industry partners have conducted dozens of TIMs. Example topics include:
  - Propulsion
  - Launch vehicle structures
  - Docking systems
  - Thermal protection systems

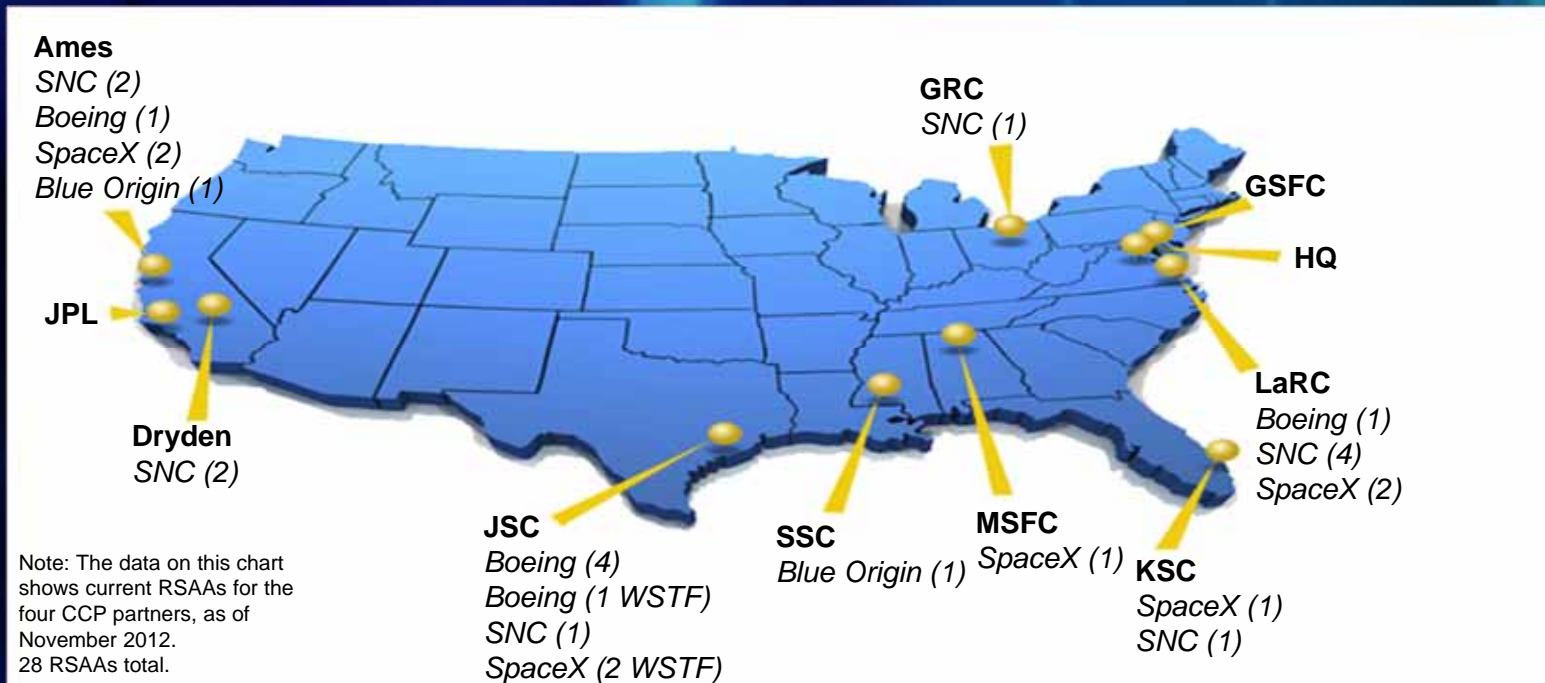


# Reimbursable Space Act Agreements (RSAAs)



## CCP Sponsored

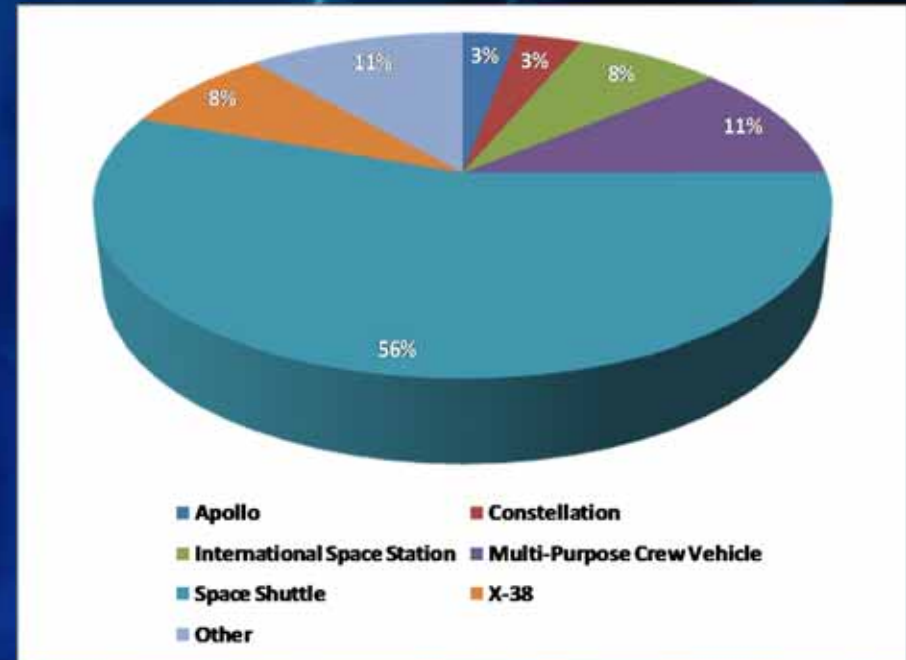
- RSAAs permit partners to use underutilized NASA facilities, personnel or equipment. NASA's costs are reimbursed by the partner.
- NASA undertakes reimbursable SAAs when it has unique goods, services or facilities that can be made available to another party in a manner which does not interfere with NASA mission requirements.



# Data Sharing



- Another way NASA transfers knowledge is through the distribution of current and historical technical products.
- To date, NASA has received nearly 1,000 requests for NASA products from its commercial crew partners, including documents, drawings, test plans and test results.
- NASA's partners can leverage these data products to accelerate their crew transportation system development efforts and to avoid "reinventing the wheel."

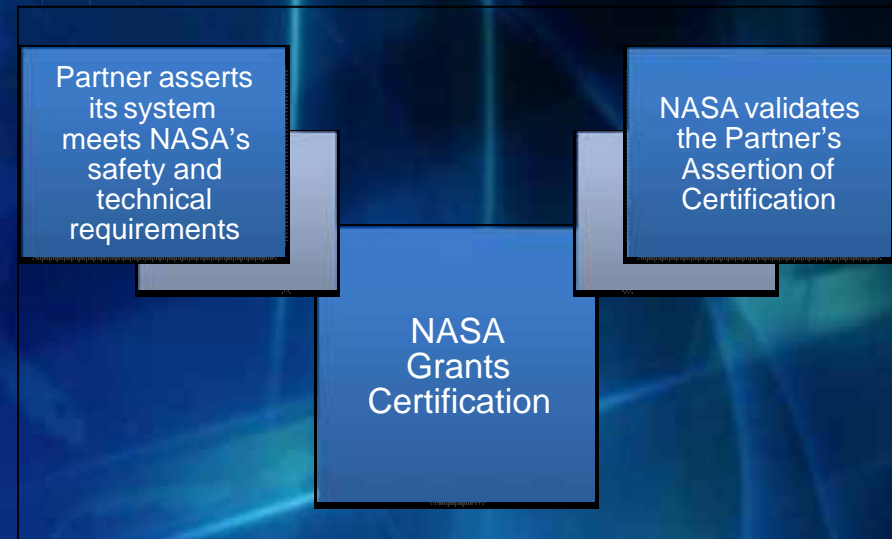


*Breakdown of Partner Data Requests by Program*

# Requirements Application



- With the recently awarded Certification Products Contracts, NASA has a mechanism to engage industry in the application of key safety and performance requirements associated with the ISS crew transportation mission.



*NASA and Industry Partner Roles in Certification*

- The Certification Products Contracts will 1) reduce the uncertainty associated with interpretation of NASA's certification requirements, 2) reduce the risk of accepting technical/safety risk later in development and 3) reduce the risk of potential schedule delays and/or cost increases.

# NASA's Complementary Strategy



The Future of American

## **HUMAN SPACEFLIGHT**



**Space  
Launch System  
and Orion MPCV**

**Deep Space  
Exploration**



**Commercial  
Crew Program**

**Low-Earth Orbit and ISS  
Research & Development**



# ***Blue Origin***

NASA Commercial Crew Program  
Kennedy Space Center

***Jan. 9, 2013***

***Rob Meyerson  
President and Program Manager  
Blue Origin LLC***



# Blue Origin Overview

BLUE ORIGIN

- Blue Origin has a long-term vision of increasing the number of people who can fly to space
- Founded in 2000 by Jeff Bezos, founder and CEO of Amazon.com
- Blue is focused on developing vehicles and technologies to lower the cost and increase the safety of human spaceflight
- Blue's incremental development plan includes:
  - Reusable systems to increase reliability and lower operating costs
  - Vertical landing for recovery and reuse
  - Beginning with suborbital systems that prove out technologies for orbital flight
- Significant private investment to date:
  - Design and development
  - Engine testing
  - Vehicle manufacturing
  - Flight testing



Design, Development and Assembly Facility (Kent, WA)



West Texas Launch Site (Van Horn, TX)



# Incremental Development

BLUE ORIGIN

- Suborbital program in flight testing stage
  - *Goddard* subscale demonstrator flown 2006-2007
  - *New Shepard* system in development
    - Propulsion Module
      - 2011 testing demonstrated boost, landing and flight to 45,000 feet/Mach 1.2
      - Development of next vehicle underway
    - Crew Capsule – successful pad escape test October 2012
- Orbital Transportation System
  - Reusable orbital Space Vehicle (SV)
    - Transport to LEO or ISS for up to seven people
    - ~22,000 lbm with crew at launch
  - Two-stage Orbital Launch Vehicle (OLV)
    - Expendable upper stage
    - Reusable first stage



2006



2011



2012



Crew Capsule

Propulsion Module

Suborbital  
New Shepard  
System



Space Vehicle

Expendable Upper Stage

Reusable First Stage

Orbital  
Transportation  
System



# Commercial Crew Development (CCDev)

BLUE ORIGIN

- CCDev1 (\$3.7M)

- Composite Pressure Vessel Testing
- Pusher Escape Development



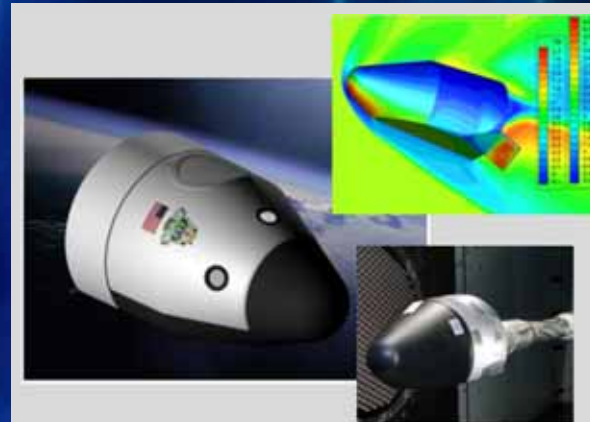
Composite Pressure Vessel Assembly



Thrust Vector Control Testing

- CCDev2 (\$22.0M)

- Space Vehicle Design Maturation Project
- Pusher Escape Risk Reduction Project
- RBS Engine Risk Reduction Project



Space Vehicle Design Maturation



Pad Escape Test



Hydrogen Engine Testing at NASA Stennis



# BE-3 Engine Risk Reduction Testing

BLUE ORIGIN

- **BE-3 Liquid Oxygen, Liquid Hydrogen (LOX/LH2) Engine**
  - 100,000-lbf thrust
  - Deep throttle
  - Restartable
  - Reusable
- **Thrust Chamber Assembly (TCA) Testing in 2012**
  - At NASA Stennis Space Center's E-1 Complex
  - Multiple tests over full throttle range
  - Accelerated BE-3 development by more than a year
- **LOX and LH2 Turbopump Testing in 2012**
  - At Blue's West Texas test facility
- **Full Engine Testing is underway**
  - At Blue's West Texas test facility
- **In-house Development**
  - Analysis
  - Design
  - Fabrication
  - Component testing
  - Engine testing



BE-3 Hydrogen Thrust Chamber Testing  
at NASA Stennis Space Center



# Crew Capsule Pad Escape Test

BLUE ORIGIN

- Integrated end-to-end test of Crew Capsule Escape System
  - Escape motor firing
  - Thrust vector control
  - Guidance and control
  - Parachute deployment
  - Landing
  - Recovery
- Fully successful test conducted Oct. 19, 2012, at Blue's West Texas Launch Site
  - Co-funded by NASA under CCDev2 initiative
  - Only powered flight test under CCDev2



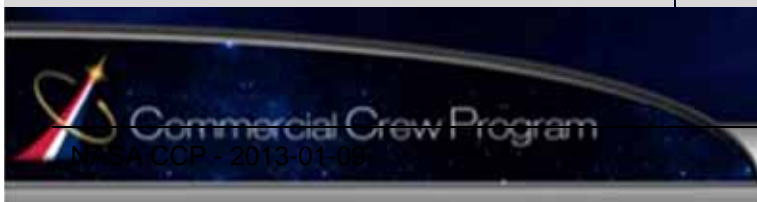
Pusher Escape Motor Firing



Descent Under Parachutes



Landing and Recovery





# Points of Contact

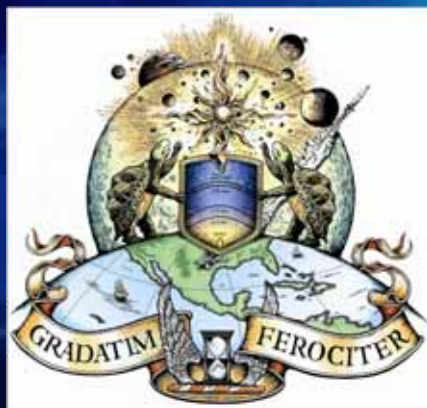
**BLUE ORIGIN**

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[www.blueorigin.com](http://www.blueorigin.com)



## **Boeing 2012 CCTS Progress and 2013 Plan**

January 2013

# CCTS Design Maturation Under CCDev2

## ■ Structures & Mechanisms Testing

- CM Pressurized Structure Producibility & Material Properties Testing for Lighter Weight Alloy (Al 7475)
- BMI Composite Material Property Development
- CM/SM Umbilical Pyrotechnic Guillotine Cutter Test
- MMOD Hypervelocity Impact Testing

## ■ Landing System Testing

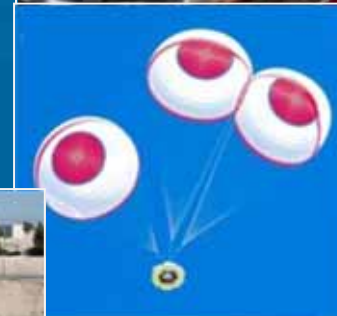
- Airbag Drop Testing
- Rotation Handle Testing
- Parachute Drop Testing
- Inflation System Development
- FHS Separation Testing

## ■ Propulsion Systems Testing

- Launch Abort Engine Hot Fire Tests
- SM Propulsion Tank Tests
- Orbital Maneuvering and Attitude Control Engine Hot Fire Test
- SM Propulsion Cold Flow Test
- SM Propulsion Helium Pressurization Flow Test

## ■ Wind Tunnel Testing

- Launch Abort Wind Tunnel Testing at NASA Ames Research Center



# CCTS Design Maturation Under CCDev2

## ■ Avionics Testing

- Launch Vehicle EDS Testing with CST-100 Avionics
- ASIF/VENUS Closed-Loop Ascent/Rendezvous Flight Simulation
- ASIL Deployment

## ■ Production and Ground Systems Development

- AI&T Site Selection (refurbished KSC OPF3)
- DELMIA Design for Manufacture and Assembly Assessments

## ■ Crew and Cargo Systems Development

- Crew Ingress/Egress Assessment
- Cargo Capability Assessment
- Crew Reach Assessment
- Crew Control Panels Layout Development
- Crew Seat Prototype Development

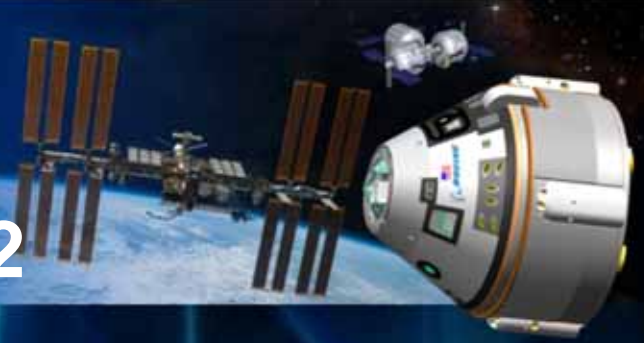


# CCiCap Base Period Major Milestones 2013-2014



2012					2013					2014											
Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
★ Aug-2012 #1 - Integrated System Review																					
Oct-2012 ★ #2 - Production Design Review																					
Nov-2012 ★ #3 - Phase 1 Safety Review Board																					
Jan-2013 ★ #4 - Software Integrated Engineering Release 2.0																					
Jan-2013 ★ #5 - Landing & Recovery/Grnd. Comm. Design Review																					
Feb-2013 ★ #6 - LVA Preliminary Design Review																					
Apr-2013 ★ #7 - Integrated Stack Force & Moment Wind Tunnel Test																					
May-2013 ★ #8- Dual Engine Centaur (DEC) Liquid Oxygen Duct Dev. Test																					
Jul-2013 ★ #9 - Orbital Maneuvering & Attitude Control Engine Dev. Test																					
Oct-2013 ★ #10 -Spacecraft Primary Structures CDR																					
#11 - Service Module Propulsion CDR ★ Nov-2013																					
#12 - Mission Control Center Interface Demonstration Test ★ Sep-2013																					
#13 - Launch Vehicle Adapter CDR ★ Sep-2013																					
#14 - Emergency Detection System (EDS) Standalone Testing ★ Oct-2013																					
#15 - Certification Plan Release ★ Nov-2013																					
#16 - Avionics Software Integ. Lab (ASIL) Multi-String Demo ★ Dec-2013																					
#17 - Pilot-in-the-Loop Demonstration ★ Feb-2014																					
#18 - Software CDR ★ Mar-2014																					
#19-Critical Design Review Board Apr-2014 ★																					

# CCTS Design Maturation Under CCiCap August through December 2012



## ■ Integrated System Review

- Established and demonstrated CCTS Vehicle and operations that meet system requirements

## ■ Production Design Review

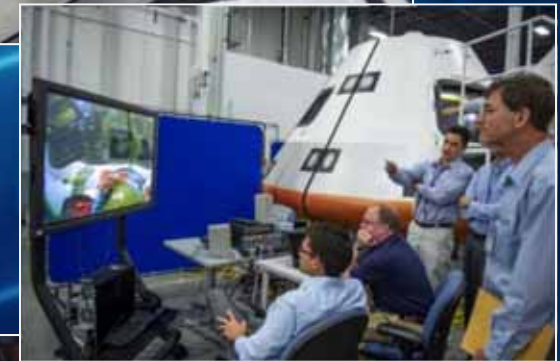
- Established the baseline plan, equipment and infrastructure for performing the manufacture, assembly and acceptance testing of the CST-100
- Leveraged successful and extensive Boeing commercial production practices

## ■ Phase 1 Safety Review Board

- Conducted a comprehensive safety review to assess conformance with NASA's Crew Transportation System certification process
- Focused on hazard reports, cause descriptions and controls

## ■ CST-100 Interior Layout Evaluation

- Completed three-day evaluation with NASA astronauts on reach and visibility of controls/displays
- Received feedback on the design of the crew seats, interior lighting and optimum layout for Crew Resource Management



# CCTS Design Maturation Under CCIcap 2013 Milestones



## Boeing's CCTS 2013 Plan

- Continue system design maturation – multiple demonstrations
- CST-100, Atlas V integration and Launch Pad modifications
- Mission Control demonstrations
- Continued development of the ULA Dual Engine Centaur
- Launch Vehicle Adapter CDR
- Continued development of KSC OPF-3





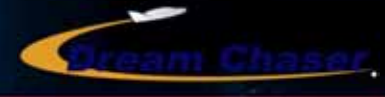
# Sierra Nevada Corporation Dream Chaser Space System



Jan. 9, 2013  
Kennedy Space Center



# 2012 Dream Chaser Highlights



To date, SNC has completed a total of 20 milestones under NASA's Commercial Crew Program. 2012 highlights include:

- ✦ Completed 10 Major Milestones
  - ✦ Engineering Test Article Structure Delivery
  - ✦ Separation System Test
  - ✦ Main Landing Gear Drop Test
  - ✦ Captive Carry Flight Test Readiness Review
  - ✦ Captive Carry Interface Test
  - ✦ Captive Carry Flight Test
  - ✦ Preliminary Design Review
  - ✦ Nose Landing Gear Test
  - ✦ CCIcap Program Implementation Plan Review
  - ✦ Integrated System Baseline Review
- ✦ Completed ECLSS Human in the Loop testing
- ✦ Completed wind tunnel testing at NASA Langley's Research Center, Marshall Space Flight Center, and Texas A&M University
- ✦ Completed Preliminary Design
- ✦ Awarded CCIcap contract in August
- ✦ Held career fairs in Colorado, Texas and Florida
- ✦ Awarded Certification Products Contract (CPC) in December
- ✦ Conducted multiple STEM outreach, education activities and speaking opportunities including participating the space shuttle Atlantis' retirement event
- ✦ Added more than 40 new employees to the Dream Chaser Team

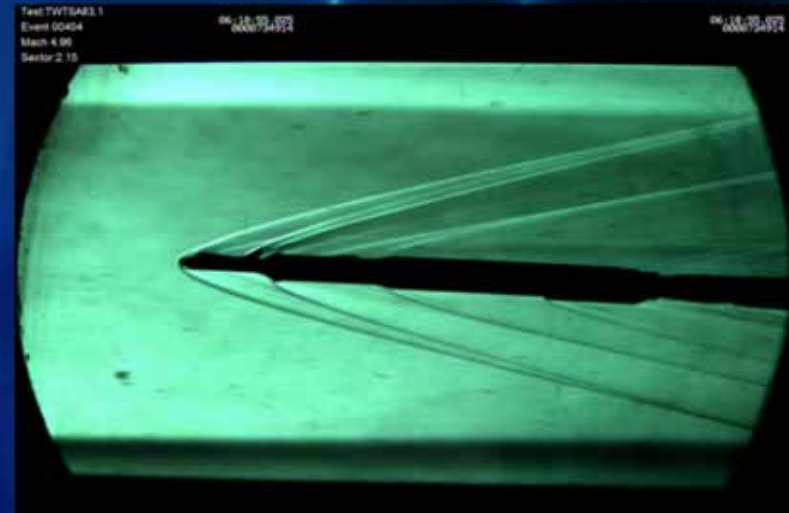




# Wind Tunnel Testing



*Integrated Stack Wind Tunnel Test*



*Integrated Stack Wind Tunnel Test*



*Slow Speed Wind Tunnel Test*



# ETA Assembly



✈ The Engineering Test Article (ETA) was assembled and tested in Colorado





# ETA Structure Complete



- ✈ The Engineering Test Article completed a captive-carry test in May 2012
- ✈ Test conducted in Colorado





# ETA Captive-Carry Test



- ✈ Captive-carry completed in preparation for the upcoming 2013 free-flight test

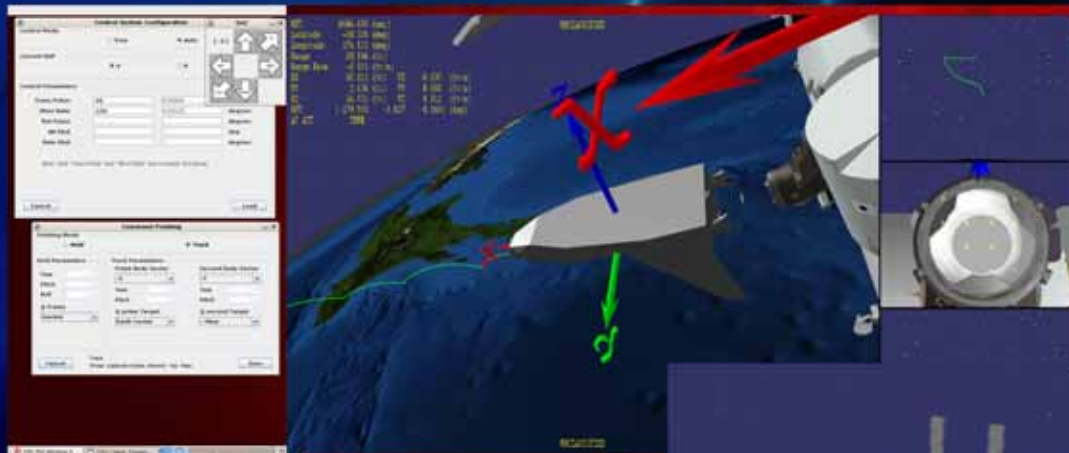




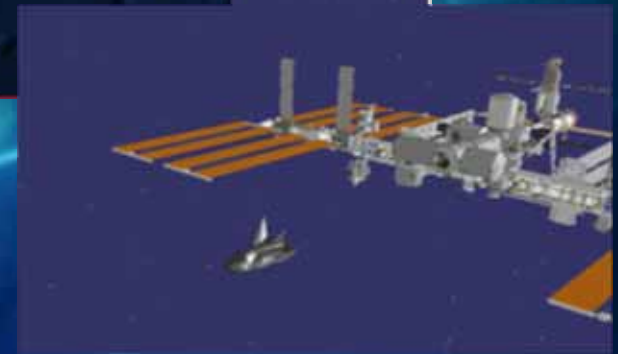
# Other 2012 Highlights



*Buffet Test Model*



*Dream Chaser Docking to ISS simulator*



*ECLSS Subsystem Testing*



*Landing  
Gear  
Testing*



# Thank you, Space Shuttle Atlantis!





# 2013 Dream Chaser Growth



- ✈ In early 2013, SNC will expand its operations with the opening of a new facilities for personnel and additional manufacturing space for the Dream Chaser Space System
  - ✈ New design, engineering and assembly building
  - ✈ Adding 50 to 100 new staff to the Dream Chaser Team
  - ✈ SNC will continue to grow partnerships with industry leaders to advance the Dream Chaser Space System. SNC currently is teamed with:
    - ✈ Seven NASA Centers
    - ✈ Multiple universities
    - ✈ Multiple world-class industry partners





# 2013 Dream Chaser Highlights



## 2013 Upcoming Milestones and Events

- ✦ Complete Integrated System Safety Analysis Review
- ✦ Complete first Flight Test of Dream Chaser, scheduled for first quarter 2013
  - ✦ Test will be conducted at Dryden Flight Research Center
  - ✦ Multiple flight tests will follow
- ✦ Continue main hybrid rocket motor testing at SNC Poway, Calif., test site
- ✦ Continue reaction control system testing
- ✦ Continue STEM and community outreach
- ✦ Other exciting news to come. Stay connected to SNC for all the latest program information!





Sierra Nevada Corporation

[www.SNCspace.com](http://www.SNCspace.com) | [www.facebook.com/SNCspacesystems](https://www.facebook.com/SNCspacesystems) | [www.youtube.com/SNCspacesystems](https://www.youtube.com/SNCspacesystems)



# SPACEX

## Commercial Crew Program Update



SpaceX was founded to advance the cause of human spaceflight



# Summary of Work Completed During CCDev2



## ■ **Launch Abort System Design, Development and Test**

- SuperDraco Engine (Demonstration Engine and Development Engine)
- SuperDraco Test Stand
- Propellant Tank
- System Components

## ■ **Crew Systems Initial Design and Development**

- Structures including seats and cabin layout
- Environmental Control and Life Support
- Spacesuits
- Launch Pad Modifications
- Mission Operations and Recovery
- Crew Displays and Controls
- Concept of Operations

## ■ **Abort and Other Analyses**

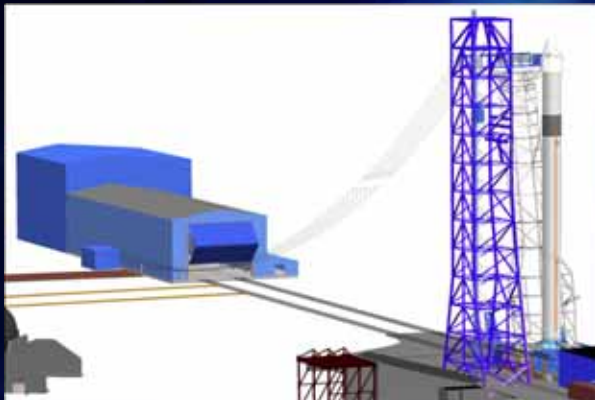
- Guidance, Navigation and Control
- Aerodynamics
- Environments
- Safety and Mission Assurance
- Human Certification Plan
- Technical Budgets and Key Performance Parameters
- Requirements Compliance

## ■ **Crew Trials**

Final CCDev2  
Milestone  
Completed in  
June 2012

# CCDev2 Overview

SPACEX



# CCiCap
























- In the CCiCap base period, SpaceX will focus on these four tasks:
  1. Complete the integrated design
  2. Hardware testing to reduce risk
  3. Ensure crew safety
  4. Prepare for NASA certification



# Base Period Milestones



## CCiCap Key Milestones

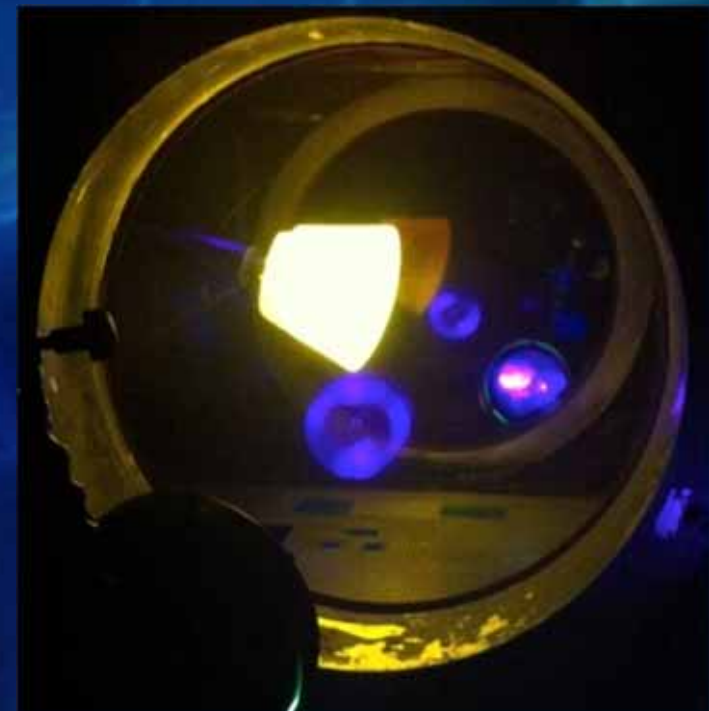
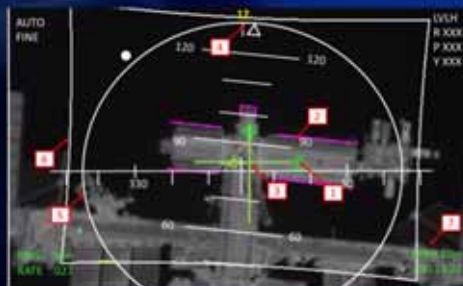
	3Q 2012			4Q 2012			1Q 2013			2Q 2013			3Q 2013			4Q 2013			1Q 2014			2Q 2014			3Q 2014												
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug											
Quarterlies																																					
																																					
Key Milestones	 CCIcap Kickoff																																				
	 Financial & Business Review																																				
				 Integrated System Req Review (ISRR)																																	
				 Ground Systems & Ascent Preliminary Design Review (PDR)																																	
							 Pad Abort Test Review																														
										 Human Certification Plan Review																											
													 On-Orbit & Entry Preliminary Design Review (PDR)																								
																 In-Flight Abort Test Review																					
																			 Safety Review																		
																						 Flight Review of Upgraded Falcon 9															
																									 Pad Abort Test												
																												 Dragon Primary Structure Qualification									
																															 Integrated Critical Design Review						
																																	 In-Flight Abort Test				

SpaceX's plan culminates in a flight to the ISS with non-NASA crew in 2015

# CCiCap Milestones Completed in 2012



1. CCIcap Technical Baseline Review – *Aug. 29*
2. Financial and Business Review – *Aug. 30*
3. Integrated System Requirements Review – *Oct. 29*
4. Ground Systems & Ascent Preliminary Design Review – *Dec. 13*



# CCiCap Milestones Planned for 2013



- **Pad Abort Test Review – *March***
  - Delivery of detailed Pad Abort Test Plan
- **Human Certification Plan Review – *May***
  - Delivery of Human Certification Plan
  - Delivery of Master Verification Plan
- **On-Orbit and Entry Preliminary Design Review – *July***
  - Preliminary design of automatic approach and docking systems
  - Preliminary design of entry, descent and landing systems
- **In-Flight Abort Test Review – *September***
  - Delivery of detailed In-Flight Abort Test Plan
- **Safety Review - *October***
  - Hazard Analysis
  - Probabilistic Safety Assessment
  - Failure Modes and Effects Analysis
- **Flight Review of Upgraded Falcon 9 - *November***
- **Pad Abort Test - *December***



# CCiCap Milestones Planned for 2014



- **Dragon Primary Structure Qualification – January**
- **Integrated Critical Design Review – March**
  - Final Design Presented prior to manufacturing orbital test vehicle
- **In-Flight Abort Test – April**





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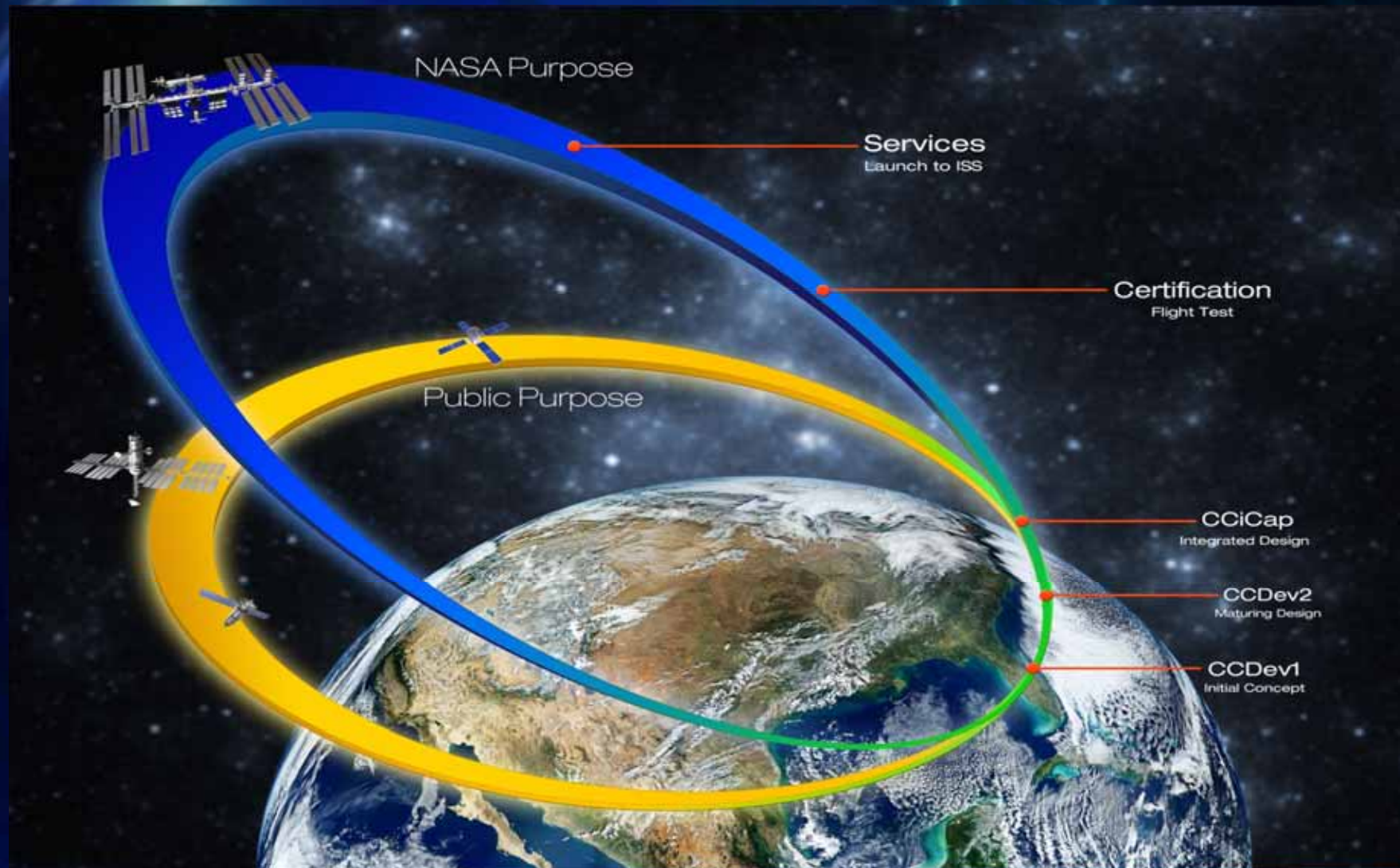
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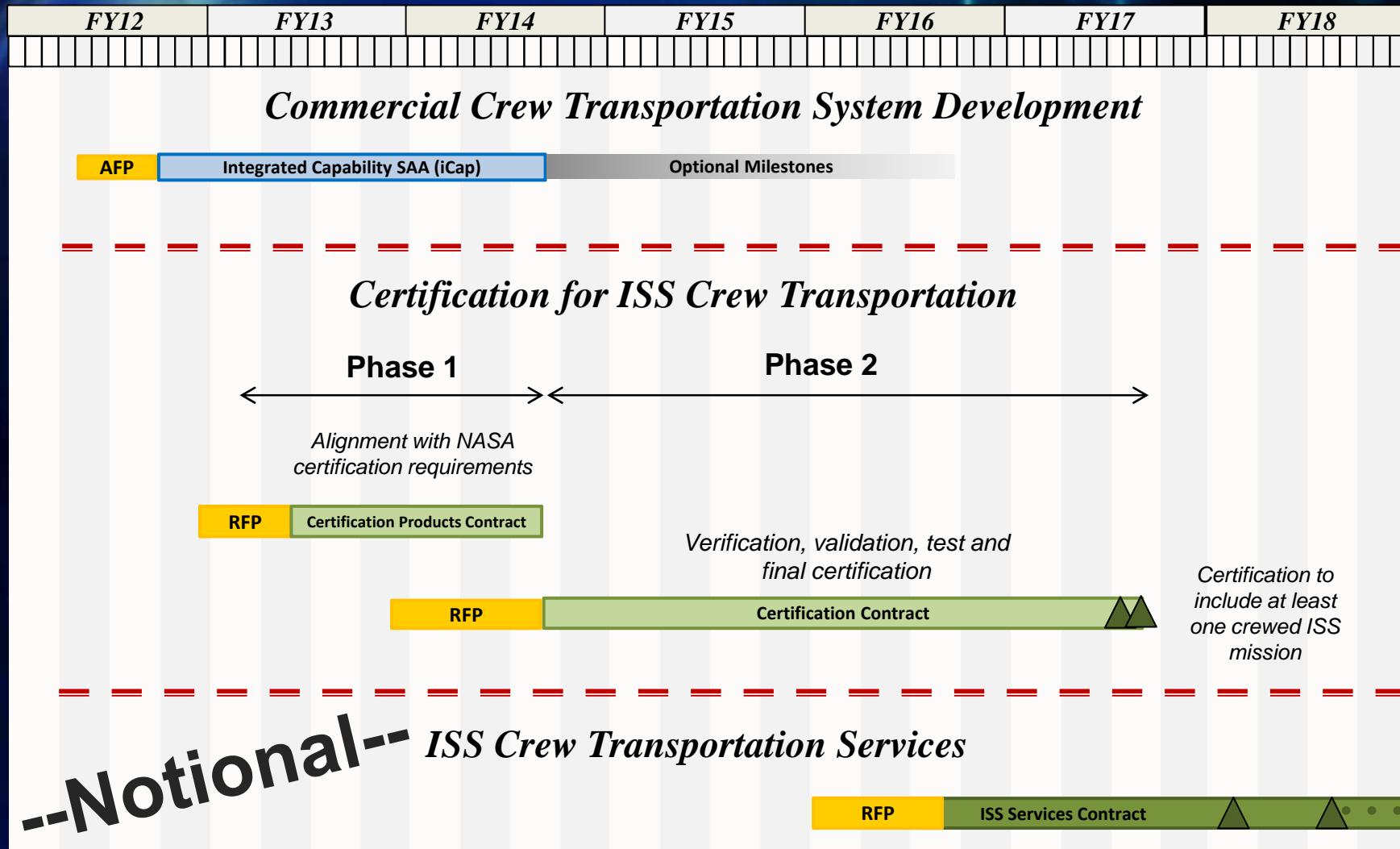
Commercial Crew Program

Jan. 9, 2013

# Commercial Crew Program Life Cycle



# Acquisition Strategy (2012)



# CCP Certification Products Contract



- ❖ Certification Products Contract is a part of a phased acquisition process to get NASA certified systems for the crewed ISS missions
- ❖ Contract Objective - Begin early, critical certification work to meet NASA Crew Transportation System (CTS) requirements
  - Maturing key certification products in Phase 1 to enable both NASA and industry readiness with level of maturity required for Phase 2
- ❖ Three Contracts Awarded Dec. 10, 2012
  - Boeing, SNC, SpaceX
  - All fixed price, each valued at \$10M or less
  - Initial and final versions of four products required and associated technical interchange
  - Payment is 40% for initial products and 60% for final products
  - Initial products in late spring 2013 and final products in spring 2014

# Phase 1 – Certification Products Contract (CPC)



## ❖ Four Product Scope

- Alternate Standards
- Hazard Analyses/Reports
- Verification and Validation Plan
- Certification Plan
- Begin the process of ISS visiting vehicle integration
- No design/development work funded through CPC

## ❖ Requirement Variance Process

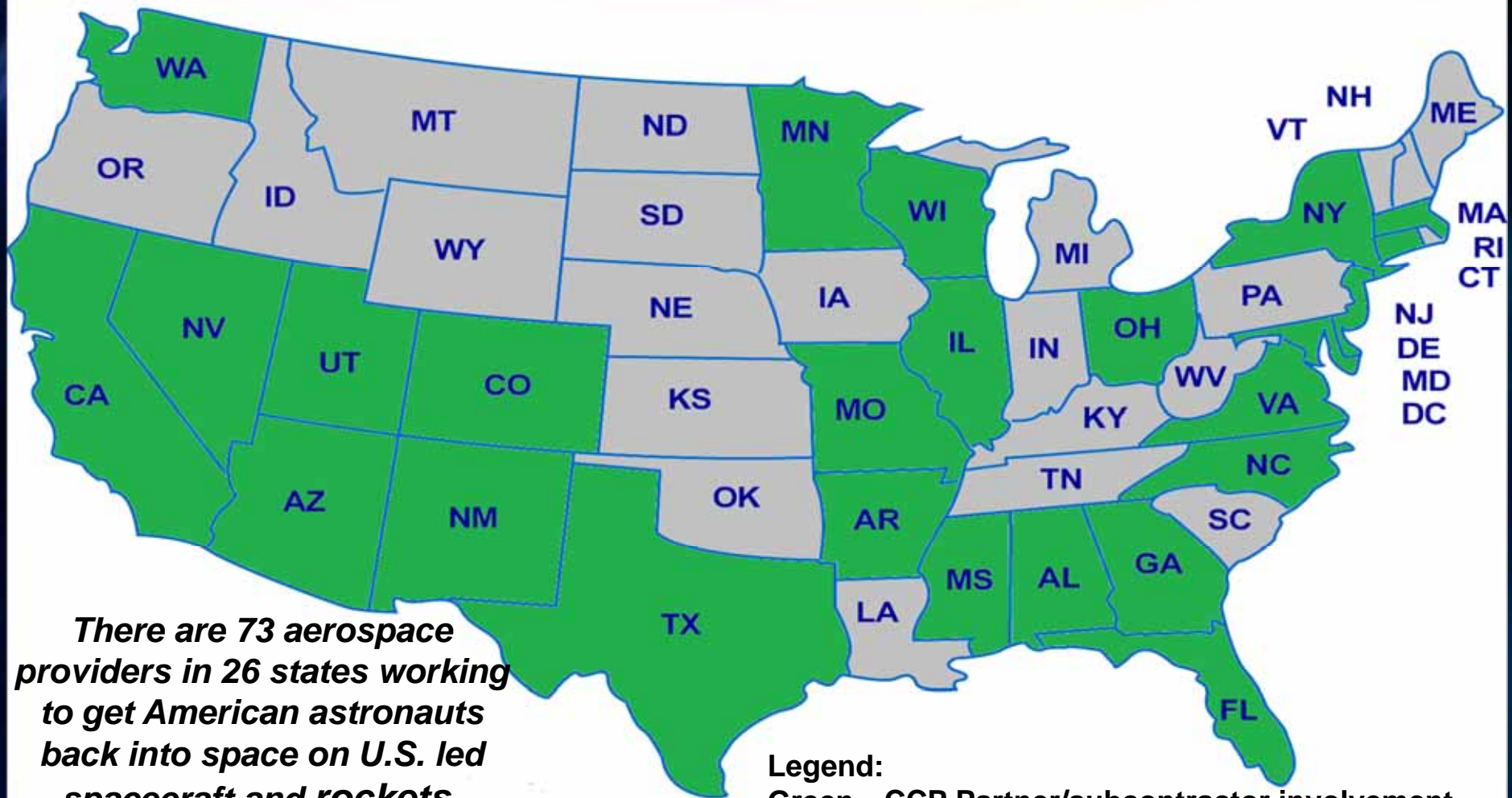
- Both CCP and industry want to be as innovative and cost effective as possible
- CCP encouraging industry partners to propose variances to NASA's technical requirements where an acceptable level of risk is maintained and ISS mission objectives are satisfied

# Next Phase Planning Steps



- ❖ NASA Certification (Phase 2) will cover all aspects of final development and certification of a crew transportation system, including design, manufacturing, testing, qualification, production and operation
- ❖ NASA/CCP intends to engage industry to help evolve and finalize plans for Phase 2
  - Request for Information (RFI) - Mid-January 2013
    - Seeking industry input on contract type and structure, approach to ISS missions and FAA licensing
  - Industry touch point with more detail discussion - March 2013
  - Draft Request for Proposal (RFP) - Summer of 2013
  - RFP Release for Phase 2 - Early Fall 2013
- ❖ Contract Award - May 2014

# Commercial Crew Program National Involvement



*There are 73 aerospace providers in 26 states working to get American astronauts back into space on U.S. led spacecraft and rockets.*

Legend:  
Green—CCP Partner/subcontractor involvement

# Questions?

